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AN

ESSAY

ON THE

LEYDEN PHIAL,

WITH A VIEW OF

EXPLAINING THIS REMARKABLE PHENOMENON

ON PURE MECHANICAL PRINCIPLES,

By which all the different Appearances of Electricity
are more ſimply demonſtrated:

TO WHICH IS ADDED, AN

ESSAY

ON

MEDICAL ELECTRICITY;

Phyſiologically inveſtigating the Nature of thoſe Complaints, where the Influence of this Fluid may prove beneficial;

ILLUSTRATED WITH
A VARIETY OF CASES.

By C. H. WILKINSON, Surgeon,
And Lecturer on Experimental Philosophy, at *St. Bartholomew's Hoſpital.*

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1798.

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TO THE
PRESIDENT,
VICE PRESIDENTS,
AND
MEMBERS,
OF THE
LITERARY AND PHILOSOPHICAL SOCIETY OF
MANCHESTER,
THE FOLLOWING
ESSAY
IS MOST RESPECTFULLY INSCRIBED
BY THEIR MOST OBEDIENT
AND DEVOTED SERVANT,
C. H. WILKINSON.

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PREFACE.

22·7·12.

WHEN the remarkable phenomenon of the charged phial was diſcovered by Cuneus, Muſchenbroek, and other philoſophers of Leyden*, no plauſible theory was advanced for its explanation previous to Dr. Franklin. From ſome experiments he was induced to ſuppoſe that electricity was a ſingle elementary fluid, which he termed electrical fire; and that its phenomena depended upon the different proportions in which it is formed; that this fire was equally diffuſed throughout all bodies, and when, upon any diſturbance, there were more than the natural quantity accumulated, this exceſs he expreſſed by the term poſitive; and when there was any deficiency, ſuch was implied by the term negative.

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* The diſcovery of the charged phial is by many aſcribed to Von Kleiſt, Dean of Camin, in Dantzic, and that he communicated this, in the year 1745, to Lieber Kuhn, a year before Cuneus's experiments. It does not appear very probable, that had ſuch a circumſtance really occurred, that it ſhould have been unknown to other philoſophers; and moreover, the experiment, as deſcribed, was not practicable by the imperfect ſtate of electrical machines at that time.

gative. Previous to this period, this circumſtance had been aſcertained by Dr. Watſon, who had adopted ſimilar terms, viz. *plus* and *minus*. In 1747, Dr. Franklin, in his letter to Mr. Collinſon, applied this doctrine to the explanation of the Leyden phial. Some difficulties which appeared in this theory, induced ſome philoſophers to form others: thus Abbé Nollet endeavoured to prove that glaſs was permeable to electricity, which experiment has been placed in a proper light by the ſagacious Beccaria; while Meſſrs. Symner, Eeles, Atwood, Bennet, De Luc, Peart, Adams, and Reid, have in ſome reſpects endeavoured to ſupport the doctrine of Du Faye, that electricity is not an elementary fluid, but the reſult of the combination of two diſtinct elements; while, on the contrary, Beccaaia, Dr. Prieſtley, Mr. Cavallo, Mr. Morgan, and the Dutch philoſophers, are powerful advocates for the Franklinian ſyſtem. Theſe I have endeavoured to curſorily examine. I have attempted to ſhew, how, in many points, all the theories hitherto brought forward are exceptionable. When I think of the great characters, Franklin, Beccaria, Prieſtley, Mahon, and others, it is with the utmoſt diffidence I venture to ſubmit to the Public doctrines the leaſt ſubverſive of theirs. As the ideas I have entertained reſpecting the Leyden Phial have appeared to ſome of my friends ſimple, and analogous to other operations of Nature, I have been induced to adopt the celebrated apothegm of Ariſtotle.

> Amicus Plato, amicus Socrates, magis tamen
> Amica veritas.

I hope I ſhall not, like the Philoſopher of Stagira, be accuſed of wiſhing to erect my own edifice upon the ruins of any other ſtructure, or, as Lord Bacon finely remarked of him, “ Like a Turkiſh deſpot, he thought he could not reign ſecure unleſs all his brethren were ſlain.”

My opinions I have endeavoured to communicate with the utmoſt perſpicuity; in my wiſh of avoiding diffuſiveneſs, I hope I ſhall not have fallen into the other extreme, as to be an example of the poet's maxim,

> ——— Brevis eſſe laboro,
> Obſcurus fio.

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AN ESSAY

ON

ELECTRICITY.

22.1.12.

As Thales conſidered motion and mind as one and the ſame principle, we can no longer be ſurpriſed, that the wonderful power of the magnet and of the amber ſhould be deemed by him the effects of animation; as if the ſoul of the *electron* or *amber*, rouſed into action by rubbing, drew into its embrace light ſurrounding ſubſtances, that when the power ceaſed, it ceaſed, becauſe the vital portion ſunk into repoſe.

So long as this idea was entertained, no farther inveſtigations were made reſpecting the real cauſe, or whether ſuch a power exiſted in other bodies, excepting the lyncurium or toumaline, mentioned by Theophraſtus, till the period of Dr. Gilbert,

of

of Colcheſter: to particulariſe the various diſcoveries of ſucceſſive philoſophers, would be foreign to the intention of this little Eſſay, and unneceſſary, as the hiſtory of this ſcience has been ſo ably executed by the learned Dr. Prieſtley.

My intention in the following pages is to endeavour to explain the phenomena of electricity on mechanical principles, to regard electricity as a fluid ſubject to laws common to all other elaſtic fluids, and to render unneceſſary the uſe of the terms attraction and repulſion *, to which no clear or diſtinct ideas can be annexed.

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* In ſome Philoſophical Eſſays I publiſhed a few months ſince, I have there fully expreſſed my opinion reſpecting the exiſtence of powers poſſeſſing the properties of *attraction* and *repulſion*. All the experiments which have been adduced in ſupport of ſuch a ſuppoſition, I preſume I have there explained on principles purely mechanical. My intention was to have purſued the ſame mode of inquiry in electricity, gravitation, magnetiſm, and chemical affinities. As my avocations will not allow of my paying proper attention to the three latter ſubjects, the inveſtigation of theſe I ſhall defer a few months longer.

Electricity in a Fluid ſui Generis, or diſtinct from any other.

Electricity is a fluid diſtinct in its properties from light, caloric, and magnetiſm.

That it is not ſimilar to light, Beccaria obſerved that electricity was not luminous when paſſing through a nearly exhauſted tube. Many experimentaliſts had remarked, that in a well-prepared barometrical tube there was no light produced by the agitation of the included mercury againſt the ſides of the Torricellian glaſs. Mr. W. Morgan has demonſtrated the truth of this by a well-arranged experiment.

When light appears attendant on the fluid, it is elicited from the bodies through which the electricity paſſes.

That it is not ſimilar to caloric is evident from its not being abſorbed and given out by bodies in proportion to their ſpecific gravities, to its velocity being ſo infinitely ſuperior to that of caloric, to its inflaming ſpirits of wine, which caloric will not*, and to its action on bodies not being univerſal, while that of caloric is.

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* A red heated body, immerſed in ſpirits of wine, will not inflame them. Flame and caloric are in many reſpects different;

That it is not ſimilar to magnetiſm, as the direction of the fluids is not only different, but the magnetic fluid is limited to iron, while all metals and almoſt all fluids are ſubject to the action of electricity.

Conductors and Non-Conductors.

Mr. Gray caſually diſcovering that ſilk would not conduct electricity, was led by this circumſtance to make experiments with other ſubſtances; hence bodies have been divided into two claſſes, *Electrics per ſe*, and *Non-Electrics.* When Franklin, by ſome experiments, was induced to ſuppoſe that electricity was equally diffuſed through all ſubſtances, he changed the terms of *Electric per ſe* into *Non-Conductors,* and Non-Electrics into Conductors.

Some experiments which I have made induce me to believe that bodies poſſeſs different degrees of electricity: that the moſt perfect conductor poſſeſſes the largeſt quantity of electricity, and the

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ent; a ſmall flame will diſcharge a Leyden phial at twice the diſtance a very conſiderable heated body will. Flame will not fire gunpowder. The expanſive power of flame is very conſiderable; a ſmall portion of ſpirits of turpentine falling gradually on a heated body, the force of the flame gives motion now to a very powerful machine.

the moſt perfect non-conductor the leaſt quantity.

It is a circumſtance well known to electricians, that in a tube exhauſted about 100 times, very ſmall portions of electricity are viſible, from the reſiſtance of the air being conſiderably diminiſhed, become more diffuſed, and paſs through a larger ſpace.

In a glaſs receiver, about ſix inches in diameter, and fourteen long, I made a quick revolution of a cuſhion, which communicated by a braſs rod to the top of the receiver, and made it rub on a piece of plate glaſs fixed on a ſtand, elevated to about the centre of the receiver; the corruſcations were very vivid. When the braſs rod was removed, and the cuſhion was left inſulated, the light produced was very faint. When a ball of ſealing wax was rubbed on the glaſs, there was no light evident. When glaſs plates inſulated were rubbed on each other, there was no luminous appearance.

When quickſilver was forced through wood by the preſſure of the atmoſphere, and the ſmall mercurial particles daſhed on the ſides of an included glaſs receiver, by ſuch an action electricity was produced*.

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* This experiment was firſt made by Hawkſbee; he called it a mercurial phoſphoreal light, and has ſince been commonly repeated. The experiment will not ſucceed, unleſs in a ſmall receiver, that the exhauſtion may be rapid.

From theſe circumſtances, I am induced to ſuppoſe, that the facility with which electricity paſſes through ſome bodies is in the ratio of the quantity they contain, and the reſiſtance to its progreſs in the inverſe proportion.

Suppoſing A B, Fig. I. to be a tube filled with air, if I force a column of air equal to the column A a, it will paſs on eaſily, and the quantity will go out of the tube. If, inſtead of ſuch a tube A B, I make uſe of a tube C D, divided by a number of partitions, in vain ſhould I attempt to force in a quantity equal to a column C d, becauſe the different partitions would prevent its acting on the air in the whole tube; thus its admiſſion or paſſage would be prevented.

The ſame mode of reaſoning may be eaſily transferred to conductors and non-conductors. Suppoſing A B a metallic rod replete with electricity, any ſucceſſive portions of electricity will only have to overcome the gentle reſiſtance of the fluid within the rod, and hence eaſily tranſmitted. When a body contains little or no electricity, not being enabled to overcome the reſiſtance of the intervening ſpaces, it would be ſimilar to the partitions of the tube C D.

We may compare conductors to water diffuſed through the vaſcular ramifications* of a ſponge, which, when preſſed on any part, an adequate portion of fluid will be exuded from all around, while non-conductors are more analogous to a wet lock of cotton, there being not that continuity in the reſpective portions, ſo that any force partially induced would not influence the whole.

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* Vaſcular ramifications of a ſponge.—When a fine ſection of a piece of ſponge is powerfully magnified, it appears like a congeries

When we receive a ſpark from a conductor, this ſpark is not identically the ſame fluid produced from the rubber by its attrition on the cylinder, but the quantum of electricity previouſly inherent in the conductor, and drove forwards by the juſt produced quantity.

The Denſity on the Conductor will neceſſarily be equal to that on the Cylinder.

This may be illuſtrated by an analogy to air. Air, we know, would be expanded to a conſiderable extent, if there were not a general equalization; thus air, included in a ſquare glaſs bottle, acts on the internal ſurface of the glaſs with a force equal to 15lb. on every ſquare inch, a force more than ſufficient to overcome the reſiſtance

congeries of exquiſitely fine veſſels; and it is owing to ſuch tubular conſtruction the power of abſorbing and retaining ſo much water.

ance of the glaſs. As the external ſurface of the glaſs is alſo ſurrounded by an equivalent force, they counteract each other; if we abſtract the circumambient air, the included elaſtic fluid evinces its power by burſting through its vitreous priſon.

So electricity, diffuſed through different bodies, is preſerved quiet, by the reſiſtance to its egreſs being in an exact ſtate of equalization; when this equality is deſtroyed, it then manifeſts itſelf in proportion to its power.

Air holding in ſolution a quantity of water, becomes a conductor in proportion to the quantity it contains; thus in very wet weather it is difficult to perform electrical experiments, then there being very little reſiſtance to the electrical fluid equalizing itſelf, ſo that any accumulation is prevented.

When the air is dry, the reſiſtance to the electric fluid is in proportion to its denſity; as action and re-action are equal, the electrical fluid equally acts on the air, and can only be accumulated to ſuch a degree till it is equal to the reſiſtance of the air. When beyond this, the reſiſtance is overcome, and the equalization reſtored; thus air condenſed, by reſiſting more will likewiſe admit of a larger accumulation of electricity; when rarefied, reſiſts leſs, and is overcome by a ſmaller quantity.

If air was a conductor, no electrical experiments could be performed; there could be no accumulation in the one part, no deficiency in another: we ſhould be deprived of all thoſe advantages which we derive from atmoſpherical electricity. This principle would then not have entered into combination with water, when converted by ſolar rays into vapour, and when having paſſed through its aërial circulation, it would no longer be precipitated with thoſe portions ſo conducive to vegetation; there would have been a dull uniformity in the atmoſpheric region, and Nature would thus have been deprived of one of her moſt energizing agents. While, on the contrary, we ſee by this wiſe proviſion, that no action takes place without unfolding a portion of this enlivening principle. The evaporation of a drop of water, as well as the concourſe of floating fields of vapour, elicit, in their diſturbance, more or leſs electricity: to this ſhowers owe their genial power, by falling on plants, on the ſurface of the earth, containing different proportions of electricity; the equalization produces that action which ſtimulates and excites vegetable life.

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The Effects of Electricity on ſuſpended Pith Balls.

It is well known to electricians, that an excited glaſs tube, or a ſtick of ſealing wax, applied near ſuſpended pith balls, will make them diverge. When they are rendered diverging by the excited glaſs tube, which, if removed, and an excited reſinous body applied, the ſeparation between the balls is deſtroyed, and they are brought into the ſtate they were in before they were diſturbed. If both the excited bodies ſhould be applied to the pith balls at one and the ſame time, there will be no ſenſible action induced; their ſtates being different, they counteract each other. Du Faye, who firſt obſerved this, ſuppoſed there were two different kinds of electricity, contrary to each other; the one he termed vitreous, and the other reſinous. As theſe ſtates appeared to Dr. Franklin to be entirely owing to the bodies having more or leſs than their natural quantity, he changed the terms, as before obſerved, to poſitive and negative.

In order to explain the phenomena of the balls, it has been aſſumed as an axiom, that electricity of a ſimilar nature repel each other; and of a contrary nature attract each other. When the pith balls ſeparate, they are ſaid to repel each other.—How vague and indefinite is the word repulſion; can we conceive that matter can act beyond where it really exiſts, that it ſhould have a power of influencing other bodies ſituated remote; not only this, but we are alſo told, that there are ſuch bodies, whoſe own conſtituent particles are ſo inimical to each other, as to have a continual niſus of receding. If ſuch were really the caſe, there would not be exiſting in Nature two homogeneous particles in a ſtate of union. Some ſay the grand principle of repulſion is fire; while Lavoiſier ſuppoſes that it is actuated by a powerful principle of attraction, and having a violent tendency to unite forced-aſunder particles of other bodies.

We are too apt to aſcribe to matter, whoſe exility eludes our ſenſes, powers incomprehenſible to us. If we ſee, from their effects, they have a tendency to ſeparate, we fancy that it is the reſult of a repulſive power circumſcribing the body; if we ſee them approximating, we ſay they are ſurrounded with an attractive power. Such a mode of reaſoning is unphiloſophical—it is explaining "*ignotum per ignotius.*" For the preſent let us wave all theſe refinements, and let us regard the electric fire as amenable to the ſame laws with common matter.

If we conſider it as ſimilar to other elaſtic fluids, all the phenomena of electricity may be eaſily explained.

If the pith balls were placed in a medium perfectly rare, no divergency would be induced by the application of any excited ſubſtance; as they are ſurrounded by a medium which reſiſts the tendency to equalization, it is ſuch reſiſtance which produces the ſeparation.

This reſiſtance is very evident in the experiment of the electric fly; the electricity pouring forth from the points in order to equalize itſelf, meets with reſiſtance in the ſurrounding air; the re-action of this medium produces the retrogade motion. When this fly is placed in an exhauſted receiver, there is no ſuch motion induced.

When a glaſs tube is excited, with reſpect to the elaſticity on its ſurface, it is in a ſtate of exceſs, and is termed poſitive. When applied to the inſulated braſs rod A B, Fig. II. the exceſs, meeting with a conducting ſubſtance, enters into it, until the braſs rod and the excited glaſs are equal; in this caſe the braſs rod has more than its natural quantity, and conſequently endeavours to equalize itſelf with the ſurrounding air. As the air is but a very imperfect conductor, the tranſmiſſion of it is very ſlow; the pith balls a b communicating with the braſs rod, are likewiſe in a poſitive ſtate of electricity; the exceſs they pour out from every point radiating from all around the balls: the reſiſtance to the evolution of this fluid, from the ſurrounding air, is the greateſt in the plate of air which lies between the two balls. Suppoſing e f, Fig. II. to repreſent the plate of air, the air muſt remain ſtationary, from being equally acted on by equal quantities of electricity, proceeding from a and b in oppoſite directions, and conſequently counteracting each other; the plate of air thus acted on by the two balls, re-acts on them; and it is this re-action which cauſes them to ſeparate.

When an excited reſinous body, or ſtick of ſealing wax, is applied, with reſpect to electricity, it is in a ſtate of deficiency, and conſequently the electricity exiſting in conducting bodies will flow towards it, in order to equalize itſelf. In this ſtate, when applied to the inſulated rod, the rod will give out a part of its natural quantity to equalize itſelf with the reſinous body; the pith balls will neceſſarily be equally negative, and will ſeparate in the ſame manner as when poſitive. In this caſe they poſſeſs leſs electricity than what is neceſſary to balance the electricity of the ſurrounding air, which, in equalizing itſelf, will gradually impart ſtreams of electricity towards the balls in a converging manner. The plate of air between the two balls will be imparting electricity in equal quantities to them both, in oppoſite directions, and by thus counteracting each other render the plate of air ſtationary; while the pith balls, ſeparate from the impulſe of the fluid, added to the re-action; as the impulſes all around the balls are exactly equal, excepting the portions between each ball having an additional re-action, which drives them into contrary directions.

In the poſitive ſtate of electricity, the ſuperabundant portion diffuſing itſelf all around, will be thrown off the ball a and b, in the direction of the dotted lines. In this caſe we ſee there is no portion of air acted on by the electricity from both balls, but the portion e f, which lies between them.

So in the negative ſtate of electricity, the air, in equalizing itſelf with the balls, will give out its exceſs in the direction of the dotted lines, converging towards the balls. As every particle which is given out will neceſſarily re-act on the air, the ſame as a cannon recoils from the re-action of the ball, no portion of air ſurrounding the balls can reſiſt this re-action ſo much as the plate of air e f. The re-action from the electricity given out to the ball a, cannot make the portion of air recede, becauſe there is the ſame re-action from the electricity given out to the ball b; hence the balls a and b meeting with greater reſiſtance from the intervening plate of air, will neceſſarily recede.

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The Effects of Attrition on Glaſs.

Glaſs, in its natural ſtate, contains little or no electricity. As we have already ſhewn, that a powerful rubbing action of two plates of glaſs would not elicit a ſingle particle of electricity; when rubbed by a ſubſtance that is replete with it, at the inſtant of attrition, when under the immediate contact of the rubber, it becomes, in the rubbing point, a conductor, which being in a comparative ſtate of deficiency with the rubber, the electricity of the rubber pours forth, in order to equalize itſelf with this new-formed conducting part. This ſtate has only a momentary exiſtence, and the powers of conducting die the inſtant the glaſs is diſengaged from the rubber; hence it is that the portion of electricity, which is diſengaged from the rubber, loads the air which ſurrounds the glaſs with a ſuperabundant portion, and, obedient to the general law of fluids, will paſs where it meets with the leaſt reſiſtance. If in this ſtate it ſhould be applied to an inſulated, conducting body, it will equalize itſelf immediately with this ſubſtance. When we excite a plate of glaſs with a rubber on one ſide, pith balls are no ways agitated by being applied to a part of the glaſs directly oppoſite to the rubber; the moment this part is diſengaged from the rubber, then the direct oppoſite portion will diſturb the pith balls with that ſtate of electricity neceſſarily reverſe to itſelf.

Thus in an electrical machine we muſt not ſuppoſe that the electricity is forced or *pumped out*, as it is ſometimes expreſſed, from the rubber, by the mere mechanical action of attrition; an inſulated braſs cylinder, by the moſt powerful rubbing, may be moved to eternity without diſengaging a ſingle particle of electricity; the portion of glaſs which is under the immediate contact of the rubber becoming a conductor, equalize itſelf with the rubber, by abſtracting a portion of its electricity, the ſame as when a bladder, half filled with air, remains in this ſtate, becauſe its denſity is equal to that of the ſurrounding medium. If the denſity of the circumambient air be diminiſhed, no longer a counteracting force to the included air, this will expand itſelf till it becomes an exact balance to the fluid around.

In order that every part of the glaſs paſſing under the rubber may be excited, it is neceſſary that it ſhould be equally preſſed; that this contact may be affected, an unctuous amalgam* is equally ſpread upon the cuſhion, preciſely upon thoſe parts immediately acted upon by the glaſs; alſo, by being of a metallic nature, is an excellent conductor, and forms that chain of connection, ſo as to allow of the electricity to immediately equalize itſelf.

The ſilk added by Dr. Nooth is a very conſiderable improvement; although the air is a bad conductor, yet if the ſpace between the rubber and the prime conductor is conſiderable, a great portion of electricity would be diſſipated. As ſilk is a non-conductor, much more reſiſts the electricity than the ſurrounding air, great care ſhould be taken that the ſilk be ſo arranged, that the moment the glaſs is diſengaged from the rubber, it ſhould be directly under the contact of the ſilk. If there ſhould be the interval of a quarter of an inch, the electricity would return by theſe to the rubber again, and thus we ſhould loſe the greateſt part.

It is from an accurate attention to theſe circumſtances that the plate machines of Mr. Cuthbertſon's are ſo ſuperior in their power to any of a cylindrical form; ſo much ſo, that in the ratio of their ſurface they produce double the effect of the cylinder; every part being more perfectly under the action of the rubber, is rendered in a more perfect conducting ſtate, and conſequently will abſtract a greater quantity of electricity from the cuſhion. When the glaſs is diſengaged from the cuſhion, the electricity will be thus ſuperiorly accumulated; in equalizing itſelf with the prime conductor, it will impart a ſuperior quantity; ſo that when a phial is charged, the inſide of the phial, the prime conductor, and the cylinder, have equal intenſities of electricity, ſo that the ſuperior the intenſity of the plate, the higher the phial can be charged.

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* Baron Kienmier's amalgam is an excellent preparation: three ounces of quickſilver, two ounces of tin, and one ounce of zinc; the quickſilver put into a wooden box, chalked, the tin and zinc melted, and poured upon the quickſilver; immediately agitate the whole together, they will all be united. This amalgam muſt be finely powdered and ſifted through a piece of cambric, or other fine ſubſtance, and mixed with a ſufficient quantity of hog's lard, till brought into the conſiſtence of being eaſily ſpread.

On this principle we may eaſily explain the reaſon why a ſmall cylinder or plate, with its proper-ſized rubber, will not produce the ſame quantity of electricity as the ſame-ſized rubber on a larger cylinder or plate, although ſo revolved that equal ſurfaces ſhall be rubbed in equal times. Let us ſuppoſe the circumference of the ſmaller cylinder or plate be thirty inches, and that of the larger ſixty inches; in order then that the ſurfaces rubbed in equal times may be equal, there muſt be two revolutions of the ſmaller to one of the larger; ſo that every inch of one machine is rubbed twice to every inch of the other; the ſame time is not allowed to every diſtinct portion of the rubbed ſurface to be reſtored to that ſtate as to admit of the greateſt degree of excitement.

What may be this peculiar change induced in glaſs by the action of rubbing, may be difficult to conceive. I have ſometimes been induced to ſuppoſe that this may, in ſome reſpect, depend on an alteration in the temperature of the glaſs, while under the immediate action of rubbing. When glaſs is much warmed, we know it then becomes a conductor; that electricity permeates it as eaſily as it does a metallic body. Let us indulge in this hypotheſis, and ſee how, by ſuch a ſuppoſition, we may explain the above circumſtance.

If the glaſs immediately under the action of the rubber ſhould poſſeſs at that time ten degrees more temperature than any other part of the glaſs, in proportion to this increaſe, it will be enabled to abſtract more electricity from the cuſhion. When diſengaged from the cuſhion, the increaſe of temperature immediately diminiſhes, and conſequently gives out the electricity. When the ſurface of the glaſs is ſmall, every part paſſes ſo quick under the rubber, that the difference between the temperature under the rubber, and the other parts of the glaſs, becomes leſs, and hence leſs quantities of electricity produced than when there is a larger ſurface. If it were poſſible to have all the parts of the glaſs twenty or thirty degrees colder than the parts immediately under the cuſhion, we moſt probably ſhould accumulate electricity to an amazing intenſity*.

There would be no difficulty in working a machine in a large receiver, filled with oxygen gas, or hydrogenous gas, as theſe gaſes contain great quantities of caloric; from ſuch experiments ſome uſeful deductions might be made.

A reſinous body, when excited, becomes not only a conductor at the moment of excitement, but retains the power a certain time afterwards; ſo that every ſubſtance with which it can come into contact of a conducting nature, or containing electricity, it will abſtract ſo much, till it becomes in a ſtate of equalization; thus it is why, in a ſtate reverſe to the glaſs, the glaſs gives it out, but the reſinous body ſtill coninues to abſtract; hence, when acting together, the reſinous body readily admitting what the vitreous body is giving out, they appear to counteract each other.

Perhaps this power of retention in reſinous bodies may be dependant on the ſame ſtate requiſite for combuſtibility.

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* *Query*. Whether a ſmall bottle cylinder would not be more excited if filled with quickſilver, ſo that, by being in contact with ſo denſe a medium, its temperature would be more equalized?

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THE LEYDEN PHIAL.

Dr. Franklin's Theory.

IN leſs than two years after the diſcovery of the Leyden Phial, Dr. Franklin endeavoured to explain the cauſe on the principle of poſitive and negative electricity. He ſuppoſed twenty particles of electricity on the inſide, and the ſame quantity on the outſide; when one particle was added to the inſide, it repelled a particle from the outſide; ſo that when the quantity withinſide was doubled, the whole on the outſide was expelled.

To this theory many objections have been made. Glaſs, according to Dr. Franklin, is not permeable to electricity, and yet is replete with it. By what power could any additional quantity within expel the ſame quantity from without, and yet no ways pervading the glaſs?

To the ſupport of this theory Dr. Franklin ſays the electric matter repels itſelf, and attracts all other matter.

When, to the ſupport of any theory, we are under the neceſſity of attempting to explain any action by the terms *repulſion* and *attraction*, ſuch is a confeſſion of our entire ignorance. If we wiſh to convey to another clear and diſtinct ideas about certain operations in nature, ſurely we would not make uſe of a mode of reaſoning ſtill more intricate than the ſubject of our inveſtigation. Nature, beautifully ſimple in all her operations, purſues not that mazy path which the cloudy genius of an Ariſtotle trod. Occult qualities and myſterious powers are no more ſcience than boiſterous epithets and turgid declamation are true eloquence. Even when the great Des Cartes produced his plain and rational theory, yet, with a prejudice almoſt national, the great mind of a Newton evinced its fallibility, by ſtill retaining Ariſtotelian abſurdities.

Even in Newton we find many expreſſions which his moſt powerful advocates cannot unfold; and yet how many there are who receive his conjectures as ſacred myſteries, and attribute their incomprehenſion to an intellectual inability, as if their eyes were blinded by that reſplendent blaze of truth upon which his eagle ſight could gaze without injury.

In the firſt point of view, the Franklinian theory appears ſimple and eaſy; when more minutely examined, it is found attended with inſuperable difficulties. A power of a body extending beyond the body itſelf, influencing other bodies without any material agency: an *actio in diſtans* is too wild a theory to be admitted, and is no ways ſupported by any analogy in nature. Some of its advocates ſay, that "flame will communicate heat through ſubſtances which are impervious to the flame itſelf." What is flame but the rapid decompoſition of caloric from oxygen gas: hence the caloric may be tranſmitted to a body, without that body being alſo enabled to produce the ſame quick decompoſition. A body muſt be heated to a certain intenſity before it can acquire this power *.

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* We might ſuppoſe, that to every particle of oxygen there is a particle of fire; that an equalization is preſerved ſo long as there is no diſturbance: acted upon all around, they equally react, and thus preſerve the balance. When any change is induced in a body, by any proceſs or diſturbance whatever, and by ſuch a change there ſhould be leſs reſiſtance to the oxygen particles in that direction than to any other, the union between theſe particles and thoſe of caloric will be deſtroyed exactly in that part where the reſiſtance is the leaſt that is in contact with the body; ſo that the caloric will be thrown upon the body, while the oxygen particles are in union with the body. If this proceſs ſhould be ſlow and gradual, as in metallic bodies, it will be calcination or oxydation. If the proceſs ſhould be rapid, the rapid ſeparation of caloric would form a fiery atmoſphere

Another argument that has been advanced, is an experiment with three equal-ſized balls. If theſe three balls are ſuſpended on three ſtrings, one elevated, and the other two balls in contact, when the elevated ball is ſet at liberty, it will act upon the ſecond ball, and the ſecond ball on the third. In this experiment, it is ſaid that the third ball is the only one which moves; the ſecond receives the impulſe from the firſt, and tranſmits the whole of the impulſe to the third, without being itſelf any ways diſturbed.

The ſame mode of reaſoning has been applied to the Leyden Phial; that the electricity accumulated on the inſide may act on the glaſs, and the glaſs, by acting on the electricity on the outſide, thus force it away.

Although this is the caſe in the congreſs of bodies, ſuch can no ways explain why there ſhould be no accumulation within, unleſs the electricity on the outſide can be conducted away.

phere about the body where expoſed to the air, and conſtitute a flame: thus the flame of a candle is preſerved in its direction from being ſo ſpecifically lighter than the ſurrounding medium, although the decompoſition is all around. The inſtant a particle is ſeparated, the very ſame inſtant it riſes up in that direction where it meets with the leaſt reſiſtance; thus all accumulating, form a cylindrical flame round the combuſtible body, and which becomes conical in that part where detached. To purſue theſe inquiries, we might eaſily explain not only the different coloured tints of the ſame flame, but alſo the different intenſities in the different parts.

Mr. Morgan has attempted to remove theſe difficulties, by ſuppoſing the electric fluid exiſts as a component part of the glaſs, and retained there by a ſtrong attractive power, as he is under the neceſſity of ſuppoſing different degrees of attraction exiſting in different parts of the glaſs. As attraction is the baſis of his ſyſtem, its reality ought to be previouſly demonſtrated, before any dependence can be placed on the ſuperſtructure.

Du Faye's Theory of the Two Electricities.

The difficulties attending the Franklinian ſyſtem, reſpecting the impermeability of glaſs, induced Meſſrs. Eeles, Symner, Atwood, and others, to adopt the idea of Du Faye, of there being two diſtinct kinds of electricities; with this difference, Du Faye ſuppoſed the electricities exiſted naturally different in different bodies, while theſe gentlemen ſuppoſe, that the two electricities are always united, and only evince their power when ſeparated; that when in union they counteract each other, ſo as in this ſtate are perfectly tranquil. When they are divided, they each have uncontrolled their ſeparate power; and their ſtrong attractive niſus to unite, is the cauſe of every electrical appearance.

By thus regarding electricity as a compound of two diſtinct principles, which, when divided, will permeate glaſs, they thus attempt to explain the Leyden Phial.

Theſe two principles they term, after Du Faye, the vitreous and reſinous electricity; and farther aſſume, that ſimilar electricities repel each other, and contrary electricities attract.

By the action of the rubber on the cylinder, the electricities of the rubber are decompoſed; that the vitreous portion is ſeparated and given to the cylinder, and takes back as much reſinous electricity; the cylinder gives out the vitreous portion it has juſt received to the conductor, and receives back an adequate portion of reſinous electricity; the conductor imparts this vitreous portion to the inſide of the Leyden jar, and takes back its reſinous portion; this additional vitreous portion repels the vitreous portion from the outſide, while the reſinous portion on the outſide is attracted within. At this period there is no electricity on the outſide, but what is uncombined; hence, with rapidity, will attract the oppoſite electricity, when it meets with no reſiſtance*.

If ſimplicity is an argument in favour of any ſyſtem, ſuch cannot be advanced in favour of this; ſo complicated a doctrine, and ſo contrary to every other chemical operation, that it need only to be heard to carry with it a conviction of its improbability. We are firſt to ſuppoſe, that by the mechanical action of the cylinder rubbing on the cuſhion, that the electricities are decompoſed and exchanged between theſe two bodies. If we ſuppoſe ſuch an action could induce ſuch a change in this part, how is the diſturbance to take place on the conductor? Electricities which ſo ſtrongly attract each other to be ſo eaſily ſeparated, and thoſe portions remaining which actually repel each other, is a chemical inconſiſtency beyond our powers of comprehenſion. If I diſengage carbonic acid from an alkali by means of the citric or oxalic acid, could it be ſuppoſed that the laſt union could be itſelf decompoſed by carbonic acid gas? If this were true, what would become of our doctrines of affinity?

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* The experiments adduced by Mr. Atwood, in his learned Analyſis, in favour of there being two electricities, will hereafter be conſidered.

Mr. Read endeavours to explain the phenomena of atmoſpherical electricity, by ſuppoſing, that wherever poſitive electricity exiſts, it muſt induce a correſponding negative ſtate; and that when the attraction of theſe two electricities is greater than the reſiſting medium, they rapidly unite, and at the point of union are inactive; to this he attributes the dark ſpot we ſee in every ſpark. If Mr. Read is not an advocate for the doctrine of the two electricities, as he has previouſly given his opinion that there is only one *elec-*

tric fluid, I cannot comprehend what is meant by the *attraction of a negative body.*

To this gentleman the philoſophical world is much indebted for his accurate meteorological obſervations. As an individual, I ſhould heartily join in the general wiſh, that he would perſevere in what he has ſo ably begun.

In the year 1791, an Eſſay appeared, not very philoſophically written, under the name of a Dr. Peart, in terms rather illiberally reprobating the advocates of the Franklinian ſyſtem. With a peculiar *modeſty* this gentleman ſays, that "*his principles and his theory alone can rationally explain the phenomena of electricity, which never will be underſtood unleſs they be admitted*[*]." If Dr. Peart means that the ſcience of electricity will be to us unknown till his principles are underſtood, then indeed it would be for ever incomprehenſible. Ether and phlogiſton are words caſually caught hold of, without any relation to the original ſignification of the words. Theſe, he ſays, " are the active principles which produce the phenomena of magnetiſm, electricity, gravitation, chemical affinities, light, fire, which he *gazes* at with admiration." It is unneceſſary making any comments on a ſyſtem ſo incoherent as this.

[*] Dr. Peart on Electricity, p. 87.

Rev.

Rev. Mr. Bennet's Syſtem.

In an elegant little production on electricity, Mr. Bennet ſuppoſes electricity may be a mixed fluid, and that one of the component parts is ſufficiently ſubtile to permeate glaſs. This decompoſition Mr. B. ſuppoſes may be effected by condenſation; that when, by the action of the machine, the electricity is accumulated in a phial, as the accumulation increaſes, the fluid, by occupying leſs ſpace, is condenſed, ſo that the portion which can permeate glaſs is forced through, and, by uniting with the ſurrounding electricity, would rarefy it, like heat diffuſed amongſt colder bodies.

This ſubtile fluid Mr. Bennet ſuppoſes may be a modification of light.

If ſuch were the caſe with electricity, how ſhould we be enabled to explain the impoſſibility of charging a phial when inſulated.

Monſ. De Luc's Theory.

Volta ſuggeſting an analogy between electric fluid and watery vapours, upon this Monſ. De Luc has endeavoured to form a ſyſtem: he ſuppoſes, that if a plate of glaſs was equally moiſt with water on both ſides, and on one ſide a quantity of ſteam was thrown, the ſteam would be condenſed on that ſide, and increaſe the quantity of water, while the fire, with which it was united, will paſs through the glaſs, and, uniting with the moiſture on the other ſide, convert it into vapour; ſo that while the water on one ſide was accumulating, that on the other ſide would be diminiſhing*. Thus he ſuppoſes the electric fluid to be compoſed of two ſubſtances; one capable of permeating glaſs, and which he calls *fluide déférent électriqae*; the other not ſo ſubtile, and which he names *la matière électrique*; and that when theſe are thrown on one ſide, the deferent fluid pervades the glaſs, uniting with the natural quantity on the ſurface, paſſes off through the leaſt reſiſting conductor.

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* Je ſuppoſe une lame de verre, à la température des corps environnans, & tapiſſée *d'ean* des deux côtés. Je ſuppoſe de plus, que des *vapeurs aqueuſes,* plus chandes que cette lame, ſe portent à une de ſes faces, que je nommerai A. A méſure que ces vapeurs arrivent au contact de la lame, il s'en décompoſe une partie; le *feu latent* libéré, ſe répand dans toute la lame, & l'eau abandonnée ſe joint à celle dont la face A étoit déjà tapiſſée. Le nouveau *feu* qui arrive à l'autre face, B, y produit l'effet contraire à l'égard de la quantité d'*eau*; car il augmente l'evaporation ſur cette face; ce qui y diminue cette quantité. *J. A. De Luc Idées ſur la Météorologie.*

To this theory there are the ſame objections as to Mr. Bennet's; and moreover, the analogy here is not very correct; for ſteam thrown on the plate of glaſs, arranged as he deſcribes, would not produce the effect mentioned.

Theory of the Editors of the Encyclopedia Britannica.

In this work the identity of *fire*, *light*, and *electricity* is endeavoured to be proved; that when light is intercepted by any opake body, and reflected, heat is produced; and from an experiment of the incorrect Monſ. Achard, they deduce, that heat in ſummer becomes electric fluid in winter. Cold is by theſe gentlemen rendered a poſitive body, and the reſult of a quieſcent ſtate of the ſame fluid; and yet, in this tranquillity, preſſes on the ſurfaces of bodies and contracts them. When this fluid diverges from a centre, it operates as heat, and then expands bodies. When it proceeds in ſtraight and parallel lines, it acts as light; but in this caſe it is only heat when converged; in a *quieſcent active* ſtate it is cold; and when in a ſtate which I do not comprehend, it produces all the phenomena of electricity.

The electric fluid thus prepared, they ſay, when it meets with an electric ſubſtance, produces a vibratory motion; when with conducting ſubſtances, a progreſſive one: thus in every charged phial there is a violent impulſe or vibration of the fluid outward from the poſitive, and inward to the negative ſide. The preſſure of the poſitive ſide, in diſcharging, yields to the preſſure of the negative ſide, and runs along the conductor; when it approaches the negative ſide of the bottle, meeting with more of the ſame kind, the current of which is directed the ſame way, both together break through the air with a violent flaſh and crack, and all appearances of electricity ceaſe.

The firſt principles which are here aſſumed reſpecting the vibratory and progreſſive motions, are too hypothetical to be admitted; and even if theſe were granted, the ſubſequent reaſoning is a tiſſue of unphiloſophical deductions. A ſyſtem ſo wild is not congenial to the uſual accuracy of Edinburgh writers. The part devoted to this ſcience ſeems to have been undertaken by one who is neither a theoretical nor practical electrician; and who, by collecting a number of ſcattered remarks, has given them in that deranged manner they appear in this work.

All the theories heretofore mentioned require as data principles which can no ways be granted; to make uſe of the words *attraction* and *repulſion*, is no more than ſaying that the inſide of a Leyden Phial can be charged when the outſide communicates with the cuſhion or the earth. When it is aſſumed, that electricity is a fluid compoſed of two principles which are decompoſed by any mechanical action, we have no illuſtrative analogy in nature.

In the ſubſequent attempt to explain the phenomena of electricity on mechanical principles, I have diveſted myſelf of terms which imply the exiſtence of myſterious powers. I regard electricity as a fluid amenable to the ſame laws as all other matter that is cognizable to our ſenſes. The theory I now ſubmit to the Public is the reſult of a variety of experiments; and any thing I have aſſumed as a datum, I hope the reaſons I have advanced will prove ſatisfactory.

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A NEW THEORY OF THE LEYDEN PHIAL.

AIR, pure and unmixed, poſſeſſes little or no electricity; in ſuch a ſtate it would form one of the beſt non-conductors. This is a ſtate in which it never naturally exiſts; it holds in ſolution more or leſs water, and as this is a conducting medium, replete with electricity, the non-conducting power of air is deſtroyed in proportion to the quantity of water with which it is united.

Let us ſuppoſe A B, Fig. 3, to repreſent a ſmall column of particles of air and electricity; the circles to repreſent particles of air, and the triangles particles of electricity. In this caſe we ſee the columns ſo equally divided, that there are four particles of air between two particles of electricity,

electricity: In this ſtate they perfectly equalize each other, and ſo long as undiſturbed remain tranquil; as if it were a tube filled with water, communicating with a bladder replete with the ſame fluid; ſo long as the reſiſtance in the tube is equal to that in the bladder, there would be an equilibrium; if the balance ſhould any ways be deſtroyed, and no change whatever could be induced without altering the counteracting powers, the difference of ſtates would appear till a reſtoration takes place.

So with this aërial column; a particle of electricity added to the particle 1, neareſt to B, cannot be added but by changing the relative ſituation of the aërial particles. The particles of air contiguous to the additional portion of electricity will have the reſiſtance of two particles on one end, and only one particle on the other. The particles of air cannot diſplace the ſingle particle of electricity without overcoming the reſiſtance of the ſecond portion of aërial particles; ſo that in an elaſtic fluid like air, the particles in the firſt column will be more compreſſed than thoſe in the ſecond; and the ſecond more than the third; and the third more than the fourth; ſo that the approximation of the aërial particles, in conſequence of the electrical addition, will be in the inverſe cubic ratio of their diſtances from the freſh added electricity.

If a conducting ſubſtance, a medium replete with electricity, and through which the electric particles meet with very little reſiſtance, be applied to the accumulated particles at B, there will be leſs reſiſtance in paſſing through the conducting body than acting againſt the particles of air.

When no ſuch conducting ſubſtance is applied, the air is agitated, is not only evident from the electrical thermometer, but alſo when the broad end of an egg ſhell, with the pellicle forming a bladder of air, lies within an inch of the circuit of a large battery, and during the diſcharge, ſwells and burſts, and which demonſtrates an expanſion of the air.

The quantum of electricity in the atmoſphere, added to the reſiſtance of the aërial particles, is always a counterbalance to the large quantity diffuſed through conducting ſubſtances. When, from any circumſtance, a larger quantity ſhould be thrown into the conducting ſubſtances, columns of electrical particles will cauſe the air to recede, there will be as many columnar lines as there are points on its ſurface; the diſtance to which it forces the air marks what is called the electrical atmoſphere.

Thus in whatever place electricity is accumulated, it is accumulated by diſpoſſeſſing the air of its ſituation; owing to this circumſtance is the formation of fairy rings and water ſpouts*.

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* Fairy rings.—In Nottinghamſhire and the adjacent countries are frequently ſeen burnt annular marks on the graſs, about four or five yards in diameter; the ſoil about theſe parts is obſerved to be richer, and funguſes abound there. The country people imagine they are formed by the glowing feet of the little fairies dancing in a ring: this is explicable on electrical principles. All the phenomena of atmoſpherical electricity depends upon the different aërial portions; from a variety of circumſtances, there may be one portion of air containing more or leſs electricity than another; in equalizing themſelves, they diſplace the intervening portions of air, and the phenomena of thunder and lightning enſues; immediately after the report, a wind is always obſerved to move towards that place. If the diſtance between two clouds ſhould be greater than the ſum of the diſtances from each cloud to the earth, the earth, as a conducting body, will be the medium of equalization. If a cloud or ſtratum of air, replete with electricity, ſhould be near the earth's ſurface, diſplacing the air all around, is equally re-acted on by the air, and conſequently will aſſume a cylindrical form. When ſtriking on the earth, that part can only be burnt which is in contact with the air, and which neceſſarily muſt be the circular line bounding the cylinder.

Water ſpouts.—Dr. Stuart, who has given ſome excellent repreſentation of water ſpouts, ſuppoſed the water drawn up by ſuctions. Dr. Franklin ſuppoſed that a vacuum was induced by concentrated currents of air, and that the water was forced up. From a variety of circumſtances they appear to be electrical columns, when diſperſed, being attended with a flaſh, and diſperſed by conducting ſubſtances. If an electrical column paſſes over water, and entirely diſplaces the air, water is a conductor, and conſequently no reſiſtance to that fluid; hence the outer air will force the water up to thirty feet, or till the column of water becomes a counterpoiſe to its preſſure. Water ſpouts, in general, are about the ſize of the maſt of a large ſhip; when they fall upon a ſolid body, as a ſhip, a maſt or part of the rigging will in general be ſeparated, there being the action of 15lb. on every ſquare inch; ſo that a water ſpout, ſix feet in diameter, will be equivalent to 5000lb. Dampier tells us that he ſaw one, ſo large in its progreſſive motion, went over a ſhip becalmed on the coaſt of Guinea, firſt threw her down on one ſide, and carried away her fore maſt, and in an inſtant paſſed to the other, and carried away her mizen maſt.

When theſe electrical columns fall on land, they produce the phenomena of whirlwinds, which tear up trees, remove hay ſtacks, &c.

When theſe columns fall on the ſcorched ſands of Arabia, they are elevated, moving along with the wind, conſtituting what are called the *moving pillars of the deſart*. In theſe heated countries the air is ſo dry, almoſt a perfect conductor, and inſulated from the earth by the parched ſand. Large extent of electric matter moves almoſt in a pure, uncombined ſtate, appearing like a bluſh in the Heavens, rapidly moving; producing all the effects of an abſtraction of air, by ſuffocating every animal expoſed to its influence: and even its effects are felt acroſs the Mediterranean, as far as the ſhores of Italy, forming the Siroco of Volney, or the Simoom of Bauce.

Of the different States of Electricity in the ſame Conductor, when brought within the Influence of an inſulated Conductor, which has more or leſs than its natural Quantity of Electricity.

Suppoſing A B, C D, Fig. 4, two braſs or other metallic cylinders, placed in a right line with each other and inſulated, if the conductor A B ſhould be poſitive, or have more than its natural quantity, and brought within an inch or two of the inſulated conductor C D, the end C will be negative, and D poſitive.

Upon a firſt view it appears difficult to conceive how there could be different degrees of electricity in a conducting body, where there is ſuch freedom for equalization.

If A B has more than its natural quantity, ſuch exceſs will form an electrical atmoſphere, as before deſcribed, round the cylinder A B. The exceſs cannot paſs to C D, becauſe of the reſiſtance of the intervening particles of air. The air being acted on, as before mentioned, by the electricity being thus accumulated on the ſurface of the conductor, the particles of electricity lying about the ſurface of the end of the conductor C a b, meets with leſs reſiſtance in paſſing into conductor C D; but the end D c d will be out of the influence of the conductor A B; having thus an accumulated quantity of electricity, will endeavour to equalize itſelf. In this caſe it will have to overcome the reſiſtance of the air D c d; on this account there will be an increaſed quantity in the end D c d; but the electricity round the ſurface C a b preſſing into the conductor, and forcing the natural quantity to the end D, will have a deficiency of electricity; thus C will be negative, and D poſitive. The deficiency in the end C cannot be ſupplied from the conductor A B, becauſe of the intervening plate of air; ſo that a poſitive conductor, thus ſituated with reſpect to another, does not immediately diſturb the natural quantity of electricity exiſting in the other conductor, but by acting on the intervening air, the electric particles diffuſed in the air not meeting with any reſiſtance in the conducting medium, paſs into this, and force forwards the natural quantity.

If A B be brought ſo near to C D as to entirely overcome the reſiſtance of the air, then C D would not poſſeſs unequal portions.

This may be illuſtrated by the following analogical experiment: the end of a poker being made red hot, when removed from the fire I placed the thermometer on the other end, and aſcertained its temperature to be 58°. I held the thermometer there while I immerſed the heated end in a veſſel of cold water; the thermometer at the cool end roſe ten degrees: thus we find that the contraction which takes place on the ſurface of the heated end, forced the caloric to the other end, and thus increaſed its temperature; ſo that in this caſe the caloric is accumulated at one end by the abſtraction of it from the other end: thus the air round the ſurface being rendered negative, and will give negative ſigns to any conductor brought within its influence.

Let us ſuppoſe one hundred particles of electricity naturally round the ſurface, C a b; as the preſſure of fluids is always equal in every direction, there is leſs reſiſtance in theſe particles of electricity entering into the ſubſtance of the conductor C D, than to re-act on the air. As C a b is already in poſſeſſion of its natural quantity, it can receive no farther addition, unleſs by removal of its natural quantity; this will be drove towards the end D c d, as there is leſs reſiſtance in this direction than in any other; for the air round the end C a b, by being thus compreſſed, will reſiſt more than the air round the end D c d; ſo that the power with which the ſurrounding medium acts on the end C a b, will be exactly equal to the reſiſtance attending the impulſion of the natural quantity of electricity forwards, added to the reſiſtance of the ſurrounding air about D c d.

Theſe

Theſe hundred particles contiguous to the ſurface C a b, are no ways equal to the accumulated quantity round the conductor B; but no more electrical particles can be forced into the end C, but what are contiguous to it; and the conductor C D not being pervious to the air, the compreſſion of the air will only be diminiſhed by the number of electrical particles thus abſtracted. In this ſtate, any body poſſeſſing its natural quantity of electricity will impart a quantity till brought into a ſtate of equalization with the ſurrounding air: thus the ſuſpended pith balls will, to equalize themſelves with the part where they are ſuſpended, loſe a portion of their natural quantity; in this ſtate the balls will not be in balance with the air which ſurrounds them; hence will diverge, as before explained.

For the natural electricity of the body will be under the ſame impulſe from the ſurrounding air as the conductor; thus feathers, pith balls, &c. will diverge by negative electricity when applied to C, and by poſitive electricity when applied to D; and theſe portions cannot equalize themſelves with reſpect to electricity, although in one and the ſame conducting ſubſtance, ſo long as the impulſe at C ſhall be equal to the reſiſtance to its egreſs at D, added to the quantity of electricity; in fact, the momenta are equal. If there is one particle of electricity in the end C drove forwards by a power equal to ten, it will counterbalance two particles at D, which could juſt overcome the reſiſtance of five.

If a non-conducting ſubſtance, as a plate of glaſs, was applied between B and C, there would be no impulſe communicated to the air contiguous to C, becauſe the impulſe from B could not overcome the reſiſtance of the glaſs; and in this caſe the conductor C D would remain undiſturbed.

The Application of theſe Principles to the Explanation of the Leyden Phial.

Let M S be a Leyden Phial, Fig. 5, inſulated on a ſtand Q; let it be coated to a, b, on each ſide, and let N M expreſs the ſingle column of air and electricity, as it naturally exiſts on the inſide, and M O a ſimilar column on the outſide. Suppoſing the proportion as before aſſumed, viz. between two particles of electricity four particles of air, and let O R be a wire, or any other conducting ſubſtance, which may be applied occaſionally to the outſide coating b O, and let P be the conducting ſubſtance, connected with the prime conductor of an electric machine.

In this ſituation it muſt appear evident that the column M N is an exact counterpoiſe to the column M O; if an additional particle of electricity ſhould be thrown into the column M N, ſuch cannot take place without producing the effects as before deſcribed.

Let 1, 2, 3, Fig. 6, expreſs three columns, ſo ſituated as to be prevented extending their lengths, by reſiſting bodies m n, o p. In the column 2 there is an additional particle of electricity; ſuch could not be forced in without compreſſing the particles of electricity and air in that column; therefore, in order to force in a particle of electricity, I muſt make uſe of a power equal to the reſiſtance. If in the third column, I ſhould force a greater number of electrical particles; by ſtill farther compreſſing the ſuperior particles of air and electricity, I ſhall have to overcome greater reſiſtance, and muſt exert power accordingly.

If, for every additional particle of electricity in the column M N, Fig. 5, a particle of electricity is abſtracted from the outſide, they will then be in a ſtate of equality. If, then, a conducting ſubſtance, as O R, be applied to the external coating, there would be leſs reſiſtance in paſſing through here than by compreſſing the air.

Inſtead of the columns of particles of air and electricity being in their original proportion, viz. between every particle of electricity four particles of air, if ſuch a quantity ſhould be accumulated in the column M N, as to be equal in number to the particles of air, then the reſiſtance to the air would be four times greater, acting on the column M b O with this additional force; ſo that whilſt the column M N acquires an increaſed power by the addition of electricity, the column M O acquires an increaſed power of reſiſtance by the abſtraction of electric particles. On this account, in the column M O, the particles of air are in a ſtate of greater approximation than the particles of air in the column M N; that this is the caſe is evidenced to the ſenſes, by the experiment afore mentioned of the aërial pellicle withinſide an egg*.

If the particles of electricity in the column M O do not communicate with ſome conductor, there can be no accumulation in the column M N.

In this caſe there is no medium through which can be forced any of the particles but the electrical; by a powerful compreſſing force caloric may be diſengaged from the air; this muſt be by a force greatly ſuperior to the accumulation of electricity; the particles of air cannot permeate ſolid bodies. If there ſhould be a free and eaſy paſſage for the electricity, then the abſtraction from the one portion will allow of the addition to another.

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* The condenſation of the air from the diſcharge of cannon or blowing up of powder magazines have been known to electrify windows.

If the Leyden jar ſhould be inſulated, ſo that the wire R O be removed, the glaſs pillar Q will not allow of any paſſage; by being a non-conductor, contains little or no electricity in itſelf, and conſequently cannot admit of any impulſe; hence the neareſt courſe will be O G, making it a column M O; but the addition of a ſingle particle of electricity added to M N, cannot overcome the longer column M G; and this muſt be overcome to admit of any increaſe in the column M N; as this cannot be done, there can be no accumulation within.

On the metallic Coating.

In the early ſtate of electricity jars were filled with water, and immerſed in the ſame fluid to a correſponding height; when the ſuperior advantages of the outſide having a metallic coating was ſhewn by Dr. Bevis, Dr. Watſon then lined the inſide with tin foil.

Atmoſpheric air, we have already obſerved, is a very imperfect conductor, and no electricity can be accumulated in this fluid, but in thoſe parts that were in contact with conductors; thus to charge a jar uncoated within, the conducting wire muſt be moved round to every part; by having the wire connected with a metallic coating, the accumulated electricity is immediately diffuſed, ſo as to be of an equal intenſity; there being no reſiſtance to the equalization, one part cannot be in a ſtate of exceſs with reſpect to another, the metallic coating having more than its natural quantity, is more than a balance to the ſurrounding air, and conſequently imparts ſo much to the aërial portion contiguous to it, till its own exceſs and the reſiſtance of the air becomes equal. The quantity of electricity imparted in the firſt inſtant by being thus diffuſed, is not of an equal intenſity with the wire connected with the prime conductor; a ſecond portion is communicated and diffuſed, and thus the proceſs goes on till the coated ſurface, the ſtratum of air, the wire, and the prime conductor, are in perfect balance; then the jar will not admit of any farther charge.

So the outſide coating, if removed, in vain could we charge the jar, unleſs over every portion of the correſponding part to the inſide coating we had a conducting body; this could no ways be ſo effectually done as by a coating all around: the impulſe upon the column M O, Fig. 5, will cauſe the electrical particles at b to act equally all around; there being leſs reſiſtance in the metallic coating, a particle of electricity is impelled ſrom thence; the loſs of any portion of electricity from any one part, the deficiency becomes general; in this ſtate poſſeſſes leſs electricity than to balance the ſurrounding air; ſo that all the electricity in the air, in contact with the coating, becomes gradually unloaded; ſo that the ſtate of the external part is preciſely the reverſe to the internal coating, both with reſpect to the coatings and the air.

Metallic coatings have hitherto been conſidered as only connecting media; they not only anſwer this important purpoſe, but likewiſe conſiderably increaſe the quantity accumulated; according to their conducting powers, they poſſeſs more or leſs electricity, hence will admit of a larger quantity to equalize them with the ſurrounding media. This is the reaſon why the diſcharge varies according to the nature of the conducting medium; a jar filled with water will not admit of the ſame charge as when coated with tin foil; the more perfect conductor the coating ſubſtance is, the higher the diſcharge: red copper is the beſt conductor yet known; if jars were lined with it, the charge would be greater than with tin foil.

Dr. Franklin was induced to believe that the coating anſwered no other purpoſe than a connecting medium; when he had charged a coated bottle of water, by pouring out the water he found the bottle was equally diſcharged. If we have a moveable metallic lining, and after charging remove the lining, and after being unloaded replace it, the diſcharge we do not find exactly equal to what it was before the diſturbance.

From this it is by no means to be inferred that the coating is only a connecting medium. When the bottle is charged, let us ſuppoſe the coating, air on the ſurface, &c. have three times more electricity than natural; in this ſtate they keep each other in balance. When the coating is drawn to the upper part of the jar, it is then in contact with air not ſo highly charged, and imparts its own exceſs; by theſe means the balance withinſide the jar and without is preſerved, for the coating evinces very little ſigns of electricity when removed from the jar. In replacing the coating, in paſſing through the air in the upper part of the jar, it gradually recovers what it had loſt, being then in a comparative diminiſhed ſtate, and thus the charge is nearly the ſame.

Of the Situation of the reſpective Coatings.

Although the utility of metallic coatings on each ſide may be acknowledged, yet the neceſſity of their being exactly correſponding and exactly oppoſing each other, in order to produce the greateſt charge, may not at firſt view appear ſo obvious.

Let A B, Fig. 7, repreſent a ſection of a Leyden pane of glaſs; if a b be the coated ſurface on one part or ſide, then d c ought to be the coated ſurface on the other, in order to produce the greateſt effect.

Let us ſuppoſe one ſide coated d c, and the ſame extent of ſurface b e on the other ſide, but not oppoſed to it; if b e is the charged ſurface, and the electric columns acting all around, but the column b A is greater than the column A d, the loſs ſuſtained by this will be the quantity of electric fluid equivalent to the reſiſtance of the column a b, being the difference between the two columns b A and A d; but e B is leſs than B c; in order to overcome the greater column B c, it will require an additional power equal to b e, the difference between B c and B e; ſo that a pane thus coated will require an accumulation of electricity on the coated ſurface equivalent to the abſtraction from the ſurface c d, and to overcome the reſiſtance a b, b e; ſo that if the difference be ſo much, as in this caſe, the plate cannot be charged, it muſt appear evident, that when the column and ſpaces on each ſide the coated ſurfaces are equal, there is leſs reſiſtance to overcome; and theſe ſpaces can only be equal when the coatings are directly oppoſite to each other.

When a jar is charged, ſuch cannot be diſcharged without the ſame quantity of electricity being reſtored to its negative ſide; if this be inſulated, we cannot by any means abſtract the accumulated portion of electricity on the charged ſide; the ſtate of the air on the one ſide is an exact counterpoiſe to the accumulated electricity on the other. If the accumulated electricity is removed, the air muſt recover its original ſituation; and this cannot be done but by means of the reſtoration of the electric particles; in the inſulated ſtate this is impracticable, and therefore the jar cannot be diſcharged. If a communication is formed between the inſide and outſide of the jar, the part of the conductor communicating with the inſide will abſtract a quantity of electricity, in order to be of equal intenſity; this will be diffuſed through the communicating rod, and immediately tranſmitted to the negative ſide; ſo that the inſtant a portion is given to the diſcharging rod at the one end, it is forced out at the other; ſo that although we may ſuppoſe it tranſmitted in different portions, as the velocity is ſo great, that the whole appears to be tranſmitted at once, the particles of air being in a ſtate of expanſion on the inſide, and of condenſation on the outſide, the rapid reſtoration produces the report *.

When a jar is about half an inch or three quarters thick, it is incapable of being charged. Let A B, Fig. 8, be the column of electricity and air on each ſide a glaſs of this thickneſs; the column A muſt act in the direction C D B; at C not only acts in the direction D, alſo e; at D

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* After the firſt diſcharge there generally remains a quantity of electricity ſufficient for a ſmall diſcharge; this is called the reſiduum, where the jar ſpontaneouſly diſcharges, the reſiduum is very ſmall to when equalized with a diſcharging rod.

The accumulated electricity in contact with the metallic coatings, in conſequence of this chain of connection, is diſcharged at once; this is not the caſe with the portions of air lying on the uncoated ſurface. When the coatings have equalized themſelves, they are then in a different ſtate to the ſtate of air above them; the inſide coating will abſtract a portion of electricity, and the outſide coating will give out ſome of its acquired electricity: this will render a ſmaller charge. Theſe ſmall charges accumulated in a battery will produce conſiderable effect. The reſiduum alone of the Haarlem apparatus, made by Mr. Cuthbertſon, melted two feet of wire.

V. Deſcription d'une très grande Machine Electrique placé dans le Muſeum de Teyler, a Haarlem, par Martinus van Marum.

acts in the direction f as well as B; and B D C being a column much longer than C A, from theſe united circumſtances they prevent any accumulation in the column A, becauſe the firſt additional portion of electricity is not ſufficient to overcome the reſiſtance of B D C. This, as in every other caſe, demonſtrates the neceſſity of an equality ſubſiſting between theſe columns, in order to admit of a proper charge.

A Leyden Phial will admit of different Charges, according to the Powers of the Machine.

To the young electrician it appears ſurpriſing why a jar cannot be as powerfully charged by a ſmall machine as it can by a larger one; the only difference would appear, that it would compenſate in time what it wanted in power. I have already ſhewn that a ſmall plate or cylinder will not accumulate ſo much electricity as a larger one, although ſo arranged as to have the ſame ſurfaces rubbed in the ſame time; when a larger machine has its proportioned-ſized rubber, the quantity produced will be proportionably greater. If in the Leyden phial we ſuppoſe a machine ſo ſmall as to throw in every excitement a ſingle particle of electricity, there would only then be formed a ſingle column. If the machine ſhould be ſo large as every excitement to pour in four particles of electricity, in this caſe the charge will be made as ſoon again, and twice the ſtrength; as acting equally every way two columns will be formed, and ſo on in the ratio of the powers of the machine: thus, by one of Mr. Cuthbertſon's two-feet plate-machines, a coated ſurface of one foot will admit of ſuch a charge as to melt two or three inches of wire, which in vain could be attempted by a cylinder of equal ſurface.

Spontaneous Diſcharge.

When the air is very dry, from the greater reſiſtance to the electric fluid, fewer columns are formed; thoſe which are formed are formed more rapidly, ſo that the accumulated electricity M N, Fig. 5, in the inſide of the glaſs, extending upwards above M, the reſiſtance between the equalization of the oppoſite column being diminiſhed, this is overcome, and the phial is ſpontaneouſly diſcharged. If we diminiſh this non-conducting power of the air, by breathing into the jar, the electricity meeting with leſs reſiſtance, by the diffuſion of this conducting ſubſtance, the accumulated particles of electricity may proceed, not only upwards, but alſo laterally in the direction 1, 2, 3, 4, Fig. 5; ſo that a greater number of columns will be formed, a greater quantity of electricity accumulated, without any ſpontaneous diſcharge.

That the accumulated electricity acts equally every way is evident from its breaking through the ſides of the glaſs, if made thin, either by a ſpontaneous diſcharge, or by determining the whole accumulation to one particular part by the diſcharging rod.

Explication of ſome Electrical Phenomena.

Mr. Atwood had obſerved, that if there were an interrupted circuit of wires, about twelve feet, connected at one end with the inſide of a jar, and the other end with the outſide, that in charging the jar ſparks of electricity appeared, as if proceeding from each end of the wire, and extending gradually to equal diſtances, till they approached each other, and were then diſcharged.

Mr. A. ſuppoſes this a demonſtration of there being two electricities, active when in a ſtate of ſeparation, and paſſive when united. This appearance is eaſily explicable on the preceding principles; in charging the jar, every additional particle thrown into the jar will force out a particle from the outſide; the inſide of the jar, in equalizing itſelf with the conducting wire, will impart ſo much as to equalize itſelf. This firſt accumulation, on account of the diviſion of the conductor, may extend ſix inches; after ſuch a diffuſion, it becomes too weak to ſtrike through the little intervening portions of air; after a ſecond excitement of the machine, it may be tranſmitted twelve inches, and ſo on, till it has arrived at ſix feet. As exactly the ſame quantity of electricity is thrown off from the outſide, the ſame appearances muſt take place, paſſing through equal ſpaces in preciſely the ſame time; ſo that each proceed ſix feet, the communication is formed, and the charge is unloaded.

When electric ſparks are paſſed through a partially-exhauſted tube, the faintneſs in the middle has been ſuppoſed to be owing to the union of the two electricities; this faintneſs is regulated by the form of the inſtrument. If a perfect cylindrical one, as is ſometimes uſed for the Guinea and Feather, and two even plates of braſs, applied one at bottom, and the other at the top, the electricity is then univerſally diffuſed, and no particular faintneſs in any part. If, as uſually made, with a ball at one end, and a point at the other, the whole is explicable on the common principle of elaſtic fluids, the electricity proceeding from the ball in a diverging direction, as it diverges muſt be fainter; the leaſt reſiſting direction it can afterwards move in muſt be in direct lines to the conducting ſubſtances; hence will appear converging, and thus concentrating will be more luminous.

Poſitive and Negative Light.

When a conducting ſubſtance poſſeſſes more than its natural quantity, in giving it out freely to the ſurrounding air will be ramified, and in the form of a bruſh.

If the conducting ſubſtance ſhould be in a ſtate of deficiency, the electricity in the air will not be ſo freely tranſmitted; it will only appear like a little luminous ſpot or ſtar on the conductor.

Theſe different appearances merely depend upon the different freedom with which the exceſs is tranſmitted.

Points.

Mr. Hopkinſon, one of the Pennſylvanian experimentaliſts, expecting that by means of points he could concentrate the electric fluid, and thus have a more powerful ſpark, was ſurpriſed to find little or none. Dr. Franklin, with his uſual liberality, having firſt ſuppoſed that this might depend on the attraction being in proportion to the ſurfaces, confeſſes that this explanation is the beſt he could offer, yet did not think it ſatisfactory.

Volta and other electricians have ſuppoſed points are coatings to an infinitely ſmall plate of air.

Upon the preceding principles, the theory of points admits of an eaſy ſolution.

Any conducting ſubſtance in a poſitive ſtate of electricity will act as a centre to the aërial portions all around, and which will recede in concentric circles; that a conductor, whoſe ſurface is large, will neceſſarily require a power to diſturb or diſplace its own electricity, in proportion to its extent of ſurface. If there ſhould be a thouſand particles of electricity in the expoſed ſurface of a conductor, it would require a proportionate number of particles to diſturb them; or if a fewer number, an additional power; if only 100, each particle muſt be impelled by a power ten times greater than if one thouſand. In a point, comparatively ſpeaking, there is but a ſingle particle; and conſequently, if the point comes to the verge of the circumference of the ſphere formed round the conducting body, it will admit of a ſingle compreſſed particle; this particle being removed, another ſucceeds, and thus the point ſilently ſteals the fluid away; while a body with a ſurface muſt enter into that ſphere, till it arrives at that part where the electricity of the air can overcome the reſiſtance of the fluid in the conductor.

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ESSAY

ON

MEDICAL ELECTRICITY.

I HAVE already obſerved, that all fluids yet known, except air and oil, contain more or leſs electricity, and will freely allow its ingreſs, as well as egreſs. As the human body is principally conſtituted of fluids, it is replete with electricity, and ſenſible to the leaſt diſturbance. A perſon inſulated, giving a ſpark of electricity, is not identically the ſame portion he received from the machine, but an equal quantity forced out of his body by the impulſe of that he received from the conductor. When thus connected with an electrical machine, a man, become a part of the conductor, participates of the intenſity, and equalizes with the whole.

Upon this conſideration, the human body we muſt regard as a ſubſtance through which, in every part, electricity is diffuſed; ſuch being the caſe, there can be no farther addition but what an adequate portion will either be tranſmitted to ſome conductor, or form an electrical atmoſphere round the body, as before deſcribed.

Obedient to the ſame general laws by which fluids are governed, the electric matter, upon any impulſe, moves in that direction where it meets with the leaſt reſiſtance; and, as being an elaſtic fluid, the force of the impulſe will be in the inverſe cubic ratio of the diſtance of any part from the line of direction.

If a perſon takes a very gentle ſhock, he only experiences an uneaſy ſenſation at the tip of his fingers; if the ſhock is a little ſtronger, he feels it about his arms; if ſtronger, it agitates his body.

It is very eaſy to comprehend why we ſhould experience the electrical ſenſation at the extremities when connected with the Leyden phial; the quantity of electricity entering the body has in that part to overcome the reſiſtance of the electricity inherent in the fingers; from the fingers the impulſe is tranſmitted through the body; the fingers which are in connection with the negative ſide of the bottle in paſſing out, has to overcome the reſiſtance of the egreſs, and thus the ſenſation is induced.

If the impulſe is more violent, the effects of the impulſe will be more extended.

In the human body we can either increaſe or diminiſh the natural quantity of electricity, or diſturb the relative ſituation of the whole.

Abbé Nollet obſerving that fluids in capillary tubes flowed quicker when electrified, on this account he ſurmiſed, that by ſuch means the circulation of the fluids might be much increaſed: he tells us that he found animals diminiſh in weight by electricity, and that a young man loſt, in five hours electrifying, ſeveral ounces more than his uſual quantity.

Kratzenſtein, Profeſſor of Halle, ſays, by means of electricity he raiſed a man's pulſe from 80 to 88.

Sauvages, the celebrated noſologiſt, aſſures us that the pulſe is increaſed about one-ſixth. Monſ. Gerhard ſays, that in irritable people it is increaſed double (V. Mem. Berlin. Acad.). Cavallo mentions that both the negative and poſitive increaſe the pulſe about one-ſixteenth. In order to aſcertain whether electricity would increaſe the pulſe, it was accurately tried by the following gentlemen, viz. Dr. Deiman, Van Marum, Van Trooſtwyk, and Cuthbertſon, with the powerful apparatus at Haarlem; the pulſe of no one was in the leaſt influenced either by negative or poſitive electricity. I have frequently tried myſelf, as well as others, when in health or indiſpoſed, yet have never obſerved any increaſe in the circulation.

The effect of electricity is, by diſturbing the natural quantity inherent in any part of the human frame, and by thus altering the action of that part, inducing certain changes.

That ſuch changes may be conducive to health, it becomes requiſite for the adminiſtrator of medical electricity, to well aſcertain the ſeat of the complaint, to know the different ſenſibilities of the different parts, and the effect of electricity upon them.

There are many complaints which would be conſiderably aggravated by the imprudent uſe of electricity, and a great number of other affections, which could no ways be benefited by this important agent, unleſs carefully applied.

To apply electricity to the region of the diaphragm in the ſame manner we would to a rheumatic affection of the extremities, what proſtration of ſtrength would be the conſequence; that exquiſitely ſenſible ſeptum by ſuch an action would be deranged in its functions, and reſpiration for a time impeded. It would not be again reſtored till the lungs were diſtended by a ſighing inſpiration, and the diſturbance ſoothed in a flood of tears.

So in paralytic affections in any derangement of the nervous ſyſtem; to produce any good effect, the impulſe muſt be made on the ſource of the complaint; in the palſied extremity to apply electricity to the foot alone, no advantage could ever ariſe; we ought in this, as in every other caſe, to attend to the ſource of the diſeaſe before we can afford the wiſhed-for relief.

Medicines are principally confined in their actions on the ſtomach, and ſome few can be communicated to the lungs; to all other interior parts we poſſeſs no power of determining any particular medicine, unleſs electricity be regarded as ſuch: this principle we can direct in what manner we pleaſe. The muſcles, ligaments, or even ſolid bones, are, as it were, capacious veſſels, affording eaſy tranſmiſſion to this fluid; and, as we can regulate the power at pleaſure, we are thus in poſſeſſion of an active, penetrating principle, by which we can produce a variety of actions in different parts.

It is a law in the animal economy, that two different actions cannot exiſt in any one part of the human frame at one and the ſame time; when the natural action is any ways altered, it will be removed by inducing another that will counteract it. We ought to be extremely careful that the action we induce be exactly proportionate to the nature of the derangement. If a part affected ſhould be in a ſtate of great irritability, or labouring under any violent inflammatory affection, the complaints would be aggravated by the diſturbance of electricity. All thoſe caſes which appear to be connected with diminiſhed powers of life, as in dull, deep-ſeated obtuſe pains, or any interruption to the functions of the nervous ſyſtem, or by the increaſe of any ſecretion, in theſe electricity is highly beneficial.

As the influence of electricity on our organization can only be aſcertained by a careful attention to its effects, thoſe caſes in which it has proved beneficial I ſhall curſorily particulariſe.

The order I ſhall adopt will be in the formation of the human frame, beginning with the head, and ending with the feet.

Of the Influence of Electricity in Affections of the Head.

In that ſpecies of head-ach which is not very acute, but attended with a ſtupor and drowſineſs, and often with a ſenſation of coldneſs in the poſterior part of the head, in theſe caſes ſome gentle ſhocks ſent from the occiput, or the hind part of the head, to the fore part, will very often afford inſtantaneous relief. The ſized jar I generally uſe on theſe occaſions contains 18 ſquare inches coated ſurface, and the electrometer, either Lane's or Cuthbertſon's, about three-eighths of an inch from the conductor; by having this admeaſurement, the quantity of electricity is aſcertained, and thus a regularity obſerved.

In thoſe ſpecies of head-achs which are attended with fever and acute throbbings, ſhocks would prove pernicious; by irritating the forehead and temples by electrical ſparks, ſo as to induce a redneſs exteriorly, the determination of blood to the interior parts would thus be diminiſhed, and relief afforded.

When the pain of the head is fixed to a point, it is called clavus hyſtericus; it is generally confined to a ſpace on the forehead, and which may be covered by a ſhilling. In affections of this nature, both ſparks and ſhocks may, with advantage, be employed. A gentleman, about 30 years of age, of full plethoric habit, and at preſent reſides in Whitehall, applied to me, between two and three years ago, for a complaint of the above nature. By means of a ſtimulant embrocation, bleeding, and the exhibition of hemlock, the complaint was removed. In about eight months after he had another attack, which continued obſtinate, notwithſtanding bleeding, cupping, bliſtering, and the moſt active remedies were made uſe of. On the fourth day after this attack I electrified the part by means of ſparks, till the whole ſurface of the part affected was almoſt in a ſtate of veſication: the relief experienced was not very conſiderable. The next day ſome very gentle ſhocks were paſſed, about 30 in number; for about an hour after they produced a general head-ach, but not violent; the fixed pain was conſiderably diminiſhed. On the third day after the exhibition of electricity, the ſame number of ſhocks was repeated, taking care that the negative ſide of the bottle communicated with that part where the greateſt action was to be induced*. The pain was nearly removed, and the ſubſequent application of a few ſparks entirely removed the complaint. Since then he has had another attack, in which electricity being early applied, the pain was ſoon removed.

Tooth-ach and Ear-ach.

I have been informed that theſe pains have been removed by electricity. I have once tried a ſmall ſhock in the tooth-ach; the pain was aggravated by the diſturbance: nor in caſe of violent ear-ach would I recommend the application of electricity to the *membrana tympani*. Strong ſparks applied to the contiguous parts will often afford conſiderable relief; in theſe caſes they act as other ſtimulating applications would; by bringing an inflammation externally, that internally will be diminiſhed.

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* There is greater action induced by the egreſs of the electric fluid than by the ingreſs; on this account, that part connected with the outſide or the negative ſide of the phial, is more acted on than the part connected with the inſide.

Gutta Serena.

When the fibrillæ of the retina have undergone that change as to be no longer ſenſible to the impreſſions of light, conſtitute what is called a gutta ſerena.

Whether the affection be in the optic nerve, or in the fibrillæ of the retina*, the ſource of the complaint is too deep ſeated to be influenced either by aura or by ſparks; thirty or forty gentle ſhocks ſhould be ſent through the retina laterally, as well as tranſverſely; this is a caſe which requires very conſiderable perſeverance. If electricity is exhibited in the earlier ſtate of this diſeaſe, a change is ſoon induced in the ocular ſpectra, and an increaſe of ſenſibility ariſes; if the diſeaſe ſhould have been of ſome years continuance, the body ſhould be thrown into a very irritable ſtate by mercury, then the retina will become conſiderably influenced by the ſtimulus of electricity.

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* When the gutta ſerena is independent of any other affection, from variety of circumſtances it appears that the fibrillæ of the retina are the only part affected; were the nerve affected, it would be difficult to explain the reaſon of the ocular ſpectra which perſons partially afflicted experience. For the theory of this fibrillæ, the reader muſt be referred to ſome Phyſiological Eſſays lately publiſhed by C. Wilkinſon.

Few we find who have ſufficient reſolution to perſevere in the uſe of this principle, when its adminiſtration for a length of time is requiſite: ſuch ought to ſeriouſly reflect, that in all derangements of the nervous ſyſtem relief can never be quickly afforded; and it ſurely muſt be more gratifying to the human mind, by adopting ſuch means as may ultimately alleviate, than by relinquiſhing themſelves to a ſtate of deſpair.

Although many caſes of confirmed guttæ ſerenæ have reſiſted every effort, yet there are many who have experienced conſiderable relief, and which may always be expected when this complaint is properly treated in its earlier ſtage.

Deafneſs.

Whether deafneſs ariſes from a relaxation of the *membrana tympani*, or a defective energy of the auditory nerve, in either caſe electricity will be found beneficial.

When the membrane is relaxed, there is generally attending a deficiency in the ſecretion of wax. Sparks ſent through a wire, covered with a glaſs tube, introduced into the meatus, will be directed towards the membrana tympani; and conſiderable advantage is often experienced by introducing the electric tube into the mouth to the Euſtachian tube.

A boy, about fourteen years of age, I had under my care, who had been deaf for five or ſix years: Electricity was applied in this manner for a conſiderable time; he was recommended to frequently eat cruſts or other hard ſubſtances; the action requiſite for ſuch a purpoſe often inducing a ſecretion of wax*, in ſix or ſeven weeks he was conſiderably relieved. I ventured in this caſe to paſs ſome very gentle ſhocks through the Euſtachian tube, the membrana tympani, and the meatus.

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* I made this obſervation from a boy I formerly had under my care for deafneſs; every means we adopted we could not induce

A gentleman who was frequently troubled with a diſagreeable humming noiſe in one ear, and which often terminated in a loud crack: This appeared to be owing to a relaxation of the fleſhy orifice of the Euſtachian tube, and occaſionally uniting; thus the air preſſing on that part of the membrana tympani towards the mouth, being thus prevented, a free egreſs would neceſſarily interrupt any regular vibratory tremors of the membrana tympani, and thus induce a ſenſation confuſed and indiſtinct. When by the action of the included air the union was ſeparated, ſuch an evolution would be attended with a kind of report: by means of a curved glaſs tube ſparks of electricity were directed to the part, and a gargle made of bark and camphor was uſed after every time electricity was employed; in the courſe of twelve days every uneaſy ſenſation was removed.

When deafneſs is congenite, the labyrinth, inſtead of being filled with water, is found replete with an inelaſtic caſeous-like ſubſtance, in-

induce a ſecretion of wax. The boy caſually indulged himſelf in eating horſe beans, generally keeping a quantity in his pocket; the ſtrong action requiſite for their maſtication at laſt induced a plentiful cenuminous ſecretion, and his deafneſs was conſiderably removed.

capable of tranſmitting any impreſſions; in this unfortunate ſtate of deafneſs electricity, as well as every other means which have been practiſed, proves inefficacious.

Paralytic Affections ariſing from an altered State of the Brain.

Paralytic affections more often originate from what Dr. Cullen terms *apoplexia nervoſa*, than from any mechanical compreſſion ariſing from the rupture of any veſſel*. In the greater number of apoplectic heads which have been examined, no effuſion has taken place; and, on the contrary, inſtances have been known where a conſiderable effuſion has taken place without any ſubſequent inconvenience *.

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* That intellectual derangement, even in conſequence of any depreſſion of the ſkull, is not to be ſolely attributed to the mechanical compreſſion as the proximate cauſe. Mr. Abernethy and ſome other eminent practitioners have inconteſtibly proved, that many extenſive depreſſions of the cranium may take place without any mental derangement; and that in ſuch caſes the trephine ſhould not be employed. In the hydrocephalus internus ſome children, we ſee, where the ſymptoms have been rapid, and yet comparatively a ſmall accumulation in the ventricles, while in others the progreſs is ſlow, and yet a very conſiderable watery depoſit: theſe ſhew that the ſtate of ſome brains is more eaſily diſturbed than in others; and compreſſion, when it produces derangement, it acts more remotely than as a proximate cauſe.

As this ſtate is the more common, is the reaſon why electricity is ſo frequently found beneficial in paralytic caſes; no action could be induced in the nervous ſyſtem, or in the brain, but by the medium of ſo penetrating a principle as that of electricity.

When the body is partially affected, an inſenſibility confined to one ſide, it is then termed *hæmiplegia*; ſuppoſing it is the left ſide which is affected, the part of the brain which is deranged is on the right ſide. If the continuation of the brain in the courſe of the ſpine ſhould be affected, then the inſenſibility will be confined to the parts below the morbid derangement.

Thus in every paralytic caſe, what part the derangement originates from, ſhould be firſt aſcertained, and the power of the electricity ſhould be regulated by this, as well as by the ſtate of conſtitution. Particulariſing one or two caſes will ſuffice for the reſt.

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* This is the caſe of a perſon who was admitted into the hoſpital; ſix months previous to his admiſſion he had an apoplectic fit, of which he recovered; the complaint for which he was admitted into the hoſpital was no ways connected or dependent upon the apoplexy: he died. On his head being examined, a conſiderable quantity of grumous blood was found in a coagulated ſtate upon the dura mater, and had all the thick diſcoloured appearance of long-effuſed blood.

Mr. Smith, of Lambeth, recommended by ——— Smirke, Eſq. R. A.: about five or ſix weeks previous to my ſeeing him he experienced, on riſing out of bed, a conſiderable numbneſs of the left hip and thigh, and ſuch an inability of walking, as to confine him to his home, attended with no pain.

Jan. 1, 1798. Sent fifty ſhocks from the lumbar vertebræ to the knee, the jar one pint, electrometer three-eighths of an inch.

2d. Electrometer at the ſame diſtance, eighty diſcharges.

3d. Ditto; now enabled to walk two miles.

4th. Electrometer three-eighths, diſcharges two hundred and thirty.

5th. Ditto, ditto one hundred and thirty.

6th. Veſications induced on the legs; applied ſpirits to them.

7th. Electrometer three-eighths, diſcharges one hundred.

9th. Quite recovered, and at this period perfectly well.

Dec. 30, 1797.—Mr. Flack, firſt horn-player at Drury-Lane Theatre, attacked with an hemiplegia, and which paralyſed the muſcles of the right ſide of the face, particularly the orbicular, the zygomatic, and buccinator, and which entirely prevented him blowing the horn.

The ſurfaces of theſe muſcles were inflamed every day by the irritation of powerful ſparks; in the courſe of a fortnight he was enabled to take his part in the orcheſtra.

Mr. Evan Ellis, an ornamental japanner in Long-Acre, about twelve months previous to his application to me, was attacked with paralytic ſymptoms, induced by the poiſon of lead; his hands were perfectly inſenſible: recommended to me by Mr. Cuthbertſon, the celebrated electrician.

A pint bottle charged, electrometer half an inch, ſent from the cervical vertebræ to the fingers forty diſcharges: the next day the hands were conſiderably ſwelled; the fleſh bruſh was recommended. Every day the number of ſhocks were increaſed; in three weeks he ſo much recovered as to be enabled to exerciſe his trade.

Some paralytic affections ſeem not to be influenced by electricity: ſome caſes I have had under my care, where the exhibition of this principle for a conſiderable time has not induced the leaſt change: whether this difference is regulated by the conſtitution or the degree of nervous derangement, I have not yet been able to aſcertain *.

Indurations of the Œſophagus and Trachea.

When the œſophagus or throat is ſo contracted as not to admit, without great difficulty, the ſmalleſt ſolid portion, and this originating from any induration near the pharynx, an abſorption may be induced by the ſtimulus of electricity. One gentleman I have at preſent under my care, from the recommendation of Dr. Baillie, and in whom, for ſome months, the capacity of the œſophagus was ſo much diminiſhed, that with difficulty even liquids were ſwallowed.

He began with a few gentle ſparks; in the courſe of four or five days very ſmall ſhocks were ſent through the induration: in about three weeks he was enabled to ſwallow ſmall portions of meat, and now the induration is very ſenſibly diſperſing.

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* To particulariſe every caſe would be ſwelling the work beyond its intended limits; here it is only purpoſed to curſorily mention thoſe complaints where electricity may prove beneficial.

In the croup, or indurations of the trachea, electricity employed early might prove beneficial; whether it would ſo or not I have not had an opportunity of trying.

Spaſmodic Aſthma.

As this appears to originate from an altered action of the air veſſels of the lungs, a gentle diſturbance of them by means of very mild ſhocks might tend to reſtore them to their original ſtate; ſo in affections of the diaphragm, a gentle ſhock ſent through here immediately removes the hiccup; and in that diſtreſsful obſtinate diſeaſe, known by the name of the diaphragmatic gout, a conſiderable alleviation might be expected: in this exquiſitely-ſenſible part the utmoſt degree of prudence is requiſite.

In atonic ſtates of the ſtomach, dyſpepſia, &c. electricity has been found very beneficial.

Relaxations of the bladder, and incontinence of urine, electricity has been found highly ſerviceable; and perhaps we are not in poſſeſſion of a diuretic ſuperior to electricity. In enlargements of the proſtrate gland, in its incipient ſtate, the curved glaſs rod introduced into the rectum, and the correſponding diſcharger to the perinæum, ſhocks may eaſily be directed through it.

Impotence.

Perhaps in no affection of the human body is the influence of electricity ſo remarkable as in this diſeaſe: the languid melancholy ſtate into which the whole ſyſtem is thrown, when the teſtes perform not their proper function, is a caſe which frequently occurs to every practitioner. The patient low, nervous, and irritable, fancies he labours under every diſeaſe he hears mentioned; he ſeems equally averſe to every exertion, as well as to any ſexual converſe; the whole frame ſympathiſing ſo powerfully with the inactive ſtate of the teſtes, itſelf becomes torpid. In this caſe the greateſt care is requiſite in the adminiſtration of electricity; the form in which it is beneficial is by an uninterrupted ſtream from a charged battery. If we were to make uſe of ſhocks through ſo delicately-conſtructed glands as the teſtes, we might ſubject them to conſiderable injury. By ſuch a gentle and continual ſtimulus the teſtes will be rouſed into their native action, the proper ſecretion will take place, and thus the languid ſtate of the whole ſyſtem removed.

In indurated enlargements of the teſtes, unattended with any inflammation, gentle ſhocks of electricity may be paſſed through them; in this caſe the teſtes are no ways ſo ſenſible as in the former, and will therefore admit of a more powerful action.

In gleets we are told that electricity has ſucceeded when the uſual remedies have been in vain employed; whether ſtimulating the lining membrane of the urethra would produce the effect, I have not had an opportunity of determining.

In obſtinate enlargements of the ingrimal glands I have ſucceeded in producing ſuppuration, when no change was induced by any other kind of application.

In caſes of ſterility it appears to me very probable that the ovaria might be ſtimulated by electricity; alſo by paſſing gentle ſhocks through the uterus and the cervix, any menſtrual ſuppreſſion or exceſs of fluor albus might be relieved. In no one of theſe laſt-mentioned caſes I cannot aſſert any thing practically; I ſhould not in the leaſt heſitate in the adoption of ſuch a plan.

With reſpect to lumbago, ſciatica, and rheumatic affections, we are not in poſſeſſion of a remedy that produces ſo quick and favourable change in theſe complaints as electricity. Many a caſe a caſe of a violent rheumatic attack I have removed in the courſe of half an hour by electric frictions, ſucceeded by ſome powerful ſparks; and I have always found the chronic ſciatica to ultimately yield to frequent repetitions. In theſe caſes it is requiſite that an excitement ſhould be kept up for a conſiderable time. Electricity, at the leaſt, ſhould be applied an hour each time, and, if poſſible, be repeated twice a day; by theſe means a conſtant action would be kept up, ſo neceſſary to the removal of the rheumatic affection.

In fixed and obſtinate pains of the joints, ſpaſmodic contraction of the muſcles, the rigidity ſucceeding a gouty attack, violent ſprains or bruiſes—to enumerate every particular caſe in which I have ſucceeded with electricity, would ſwell out this work beyond its intended limits. Theſe are the mere outlines of a plan which I purpoſe hereafter to more minutely attend to. I have requeſted many of my medical friends, who are in the habit of applying electricity, to favour me with every caſe worthy of notice; and communications of the ſame kind from ſtrangers would be eſteemed a favour. By thus uniting the obſervations of others with my own, we may perhaps be hereafter enabled to unfold the action of this univerſal principle on our organization, and reduce the ſcience of medical electricity to ſome ſyſtematic order. I hope, however, I ſhall not be accuſed of any illiberal prejudice in ſeriouſly cautioning every perſon who may be induced to make trial of electricity, that ſuch be adminiſtered under the immediate direction of a regular medical character. The application of ſo important an agent to the animal economy ſhould not be left to the diſcretion of one who only comprehends the management of a machine, no more than the treatment of a ſerious diſeaſe ſhould be confided to one whoſe knowledge is limited to the mere compounding of medicines.

Mr. Birch and Mr. Hayes are the only medical perſons who have philoſophically ſtepped forward to reſcue this valuable principle, in a medical point of view, from improper hands. Not only this, but alſo many other important branches, which ought to be ſuperintended by profeſſional people, are unfortunately conſigned to mechanics, who cannot be expected to be enabled to alleviate the ſufferings of any one. It is a duty incumbent on the Faculty, it is a call upon their humanity, to care fully ſuperintend every derangement of the human frame, whether it be a ſimple excoriation of the ſkin, or a diſeaſe that divides the thread of life.

are acquainted [illegible] requisite in e- [illegible], Connecting [illegible] properties, who may [illegible] [illegible] that each be superintended [illegible] the [illegible] direction of a regular medical character. [illegible] application of [illegible] annual account [illegible] the [illegible] [illegible] language is [illegible]

Mr. [illegible] and Mr. [illegible] only medical [illegible] stepped forward [illegible] Not only [illegible] important [illegible] superintended by professional [illegible] cannot be expected [illegible] It is only [illegible] in the Faculty [illegible] a case [illegible] of the [illegible] whether [illegible] of the skin, or a disease that [illegible]

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AN ESSAY

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By C. Wilkinson,

AN ESSAY ON HEAT,

In which will be examined the different Theories of Bacon, Boyle, Newton, Halley, Douglas, Martine, Mortimer, Buffon, Marat, Franklin, Black, Stevenſon, Cleghorn, Irvine, De Luc, Crawford, Morgan, Elliott, Lavoiſier, Cavendiſh, and Count Rumford: Being an Attempt to demonſtrate that all the different States in which Heat has been unfolded by theſe Philoſophers, are explicable on the ſame Principles to which every Kind of Matter is amenable:

To which will be added, Obſervations on the Graduations of Thermometers, with the Account of ſome Experiments, which evince that the preſent Thermometrical Diviſion does not accurately expreſs the proportionate Intenſities of Heat.

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MEDICAL ELECTRICITY.

THE beneficial effects which have been experienced by the application of electricity in variety of diſeaſes, render it neceſſary for every practitioner to medicinally examine this pervading principle.

As our knowledge of this branch of philoſophy is yet in its infancy, it requires the united obſervations of many individuals before its influence on our organization can be well aſcertained. Every complaint in which it may be advantageouſly employed ſhould be accurately characteriſed, and its effect in every ſtage of the diſeaſe carefully ſtated.

With ſuch a profeſſional conſideration, Meſſrs. WILKINSON and REES, Surgeons, have fitted up at their houſe, No. 10 and 11, Leiceſter Street, Leiceſter Square, an appropriate and extenſive apparatus.—By employing electricity on ſo large a ſcale, they flatter themſelves, they ſhall hereafter be enabled to make ſome uſeful inferences.

Every caſe they purpoſe to accurately mark down, to obſerve the ſtated periods when any effects are induced, the degree of power employed, and the requiſite time for its application particulariſed.

To accommodate thoſe who prefer the adminiſtration of electricity at their own houſes, Meſſrs. W. and R. have arranged a number of portable electric machines, which they equally ſuperintend.

22·1·14.

FINIS.

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ERRATA.

Title page, *of* the Author, *reaa by* the Author.
Pref. p. 5, Note, *l.* 4, *Lieber Kuhn, read Lieberkuhn.*
Page 6, *l.* 20, *Beccaaia, read Beccaria.*
—— 3, Electricity *in* a fluid, *read is* a fluid.
—— 12, *l.* 18, *elaſticity, read electricity.*
—— 16, *l.* 16, *equalize, read equalizes.*
—— 37, Note, *l.* 7, *depends, read depend.*
—— *l.* 12, *enſues, read enſue.*
—— 38, *laſt l. Bauce, read Bruce.*
—— 68, Note, *l.* 6, *this* fibrillæ, *reaa theſe* fibrillæ.
—— 71, Note, *l.* 4, *cenuminous, read ceruminous.*

B M